Image forming device

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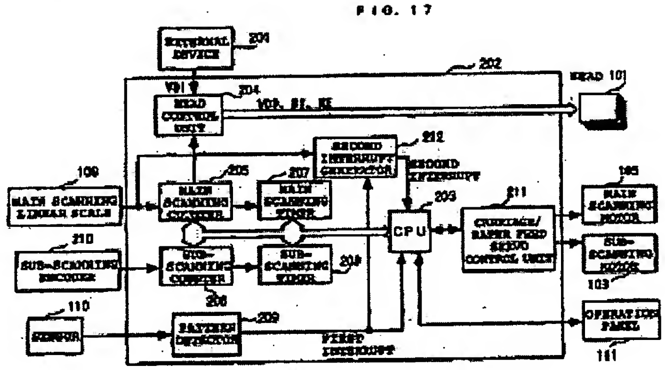
A head (101) prints a predetermined test pattern under the control of a head control unit (204) in order to precisely detect a head deviation when a head has been changed, the printed test pattern is read by a sensor 110 and detected by a pattern detector (209). Every time an interrupt signal corresponding to the edge of a detected pattern element is input to the CPU (203), a value of a main scanning counter (205)/main scanning timer (207) (and/or a sub-scanning counter (206)/sub-scanning timer (208)) is read, the printing position of each pattern element is detected from the value, and the mounting deviation of the head is calculated based on the detection result of the printing position of each pattern element printed by the head. The vertical bar of a test pattern may be printed in multiple passes. A plurality of edges may be detected at different longitudinal positions of the bar and the detected results are averaged to determine an edge position.

FIG. 17



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Description of corresponding document: **EP1195247**

Technical Field

[0001] The present invention relates to an image forming device that forms an image with the ink jet recording method.

Background Art

[0002] In the ink jet recording method, pulse signals are applied to a heater disposed in an ink-filled nozzle to heat the heater, to boil ink, and to cause the boiled ink to increase the vapor pressure to jet ink. To use this method on an image forming device, a plurality of nozzles are arranged to form one recording head, and a plurality of recording heads (for example, for jetting ink in cyan, magenta, yellow, black, and so on) are combined, to form a full-color image.

[0003] Conventionally, when forming an image using a plurality of recording heads by the ink jet recording method, the problem is that a horizontal deviation between any two recording heads, as shown in FIG. 14(a), is sometimes introduced when the recording heads are mounted on a carriage at a factory at shipment time or when a service engineer or a user replaces one or more recording heads. (In the example shown in the figure, the recording head of cyan (C) is deviated from the correct position by W). This deviation sometimes generates vertical stripes at print time and results in an unevenly printed image. Similarly, a vertical deviation between any two recording heads introduced when the heads are mounted, as shown in FIG. 14(b), sometimes generates horizontal stripes and results in an unevenly printed image.

[0004] In addition, on a device that uses a linear scale for establishing ink jet synchronization to jet ink at correct positions in the main scanning direction of the recording head, a jet position deviation (W2 + W3) may occur during forward and backward printing depending upon the movement speed of the carriage, sometimes resulting in an uneven image printing. This deviation is caused by a delay generated before the ink is jetted from the time of passing the slit position as shown in FIG. 14 (c).

[0005] Therefore, when a color registration error (hereinafter called a registration deviation) occurs through the recording head replacement or for some other reasons, the individual recording heads must be registered (i.e. registration adjustment). A registration deviation amount must be detected before making the registration adjustment. There are two methods of detecting registration deviation amounts: one is to print a particular test pattern, designed to make a registration deviation readily detectable, on paper so that human beings can check the print result to manually detect a registration amount, and the other is to cause a sensor to read a test pattern to detect a registration deviation.

[0006] The technology for reading the test pattern via a sensor is disclosed in Japanese Patent Laid-Open Publication No. Hei 7-323582. As shown in FIG. 15, the

base recording head, one of a plurality of recording heads, and each of the other recording heads print a pattern made up of two parallel bars (pattern elements) to allow the sensor to read the same position of the parallel bars twice to detect the recording head deviation amount. That is, in the first scan, the sensor senses the width of each pattern element to calculate the center dot position thereof. Then, in the second scan, the sensor senses the width W1 between the pattern elements of the base head, based on the center dot positions of the pattern elements. Repeating the above-described operation for the pattern element of the base head and those of the other heads to calculate the widths (distances) W2, ..., between the pattern elements of the base head and those of the other heads. Then, the head deviation amount É
EMI3.1
W is calculated based on the difference of those widths.

/[0007] To do so, a comparator 1502 converts the analog signal, which is output from a sensor 1501, into a binary (bi-level) signal as shown in FIG. 16. In the first scan, this binary signal is sampled in a predetermined timing in accordance with a timer 1503. Each time a pattern element is read, a CPU 1505 references the value of the timer 1503 to read the pattern width data of each of two pattern elements. After the scan is terminated, the distance from the edge of the pattern element to the center dot is calculated from the scan speed and the sampling frequency, based on the width data of each of two pattern elements. After that, setting the center value of each pattern element in the timer 1503 immediately before the pattern is read in the second scan causes the timer 1503 to output a carry signal at the time the carriage reaches the center position of the pattern element. By operating a timer 1504 using this carry signal, the distance between the center dot position of a pattern element and that of another pattern element is calculated. This is done for the pattern elements of the base head and for the pattern elements of the base head and other heads to calculate the head deviation amount É
EMR3.1
W./

[0008] However, in this case, the signal is sampled in a predetermined timing. Therefore, the carriage speed varies during carriage scanning, from scan to scan, or from device to device due to various mechanical factors such as the tension of a drive belt connecting the carriage and the motor. This variation is accumulated in the sampling results, sometimes affecting the precision of registration adjustment. In addition, detecting each pattern-to-pattern width W1, W2, ... requires the carriage to scan twice, thus requiring a long detection time and, at the same time, doubling the accumulation variation.

[0009] This applies also to the paper conveyance direction. Variations in the paper conveyance roller diameter, eccentricity, and gears connecting the motor to the roller generate accumulation variations in the accumulated sampling results.

[0010] In view of the foregoing, it is an object of the present invention to provide an image forming device capable of precisely detecting a recording head deviation when the recording head has been replaced.

[0011] In addition, variations in the shape or the direction of nozzles, introduced when manufacturing the recording head, will cause ink droplets to be jetted, not in exactly correct positions in a straight row as shown in FIG. 23(a), but in positions

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shifted vertically and/or horizontally as shown in FIGS. 23(b)-23(d). In the method described above in which a test pattern is read by the sensor to detect a registration deviation amount, two parallel pattern elements are printed by the base head and each of other heads. Then, the sensor reads the width of each pattern element from the edges of the pattern as well as the distance between the centers of the pattern elements of the base head and each of the other heads. Therefore, variations in the edges of pattern elements are generated as described above, and those variations generate read errors.

[0012] Also, when mounting a recording head 101 on a carriage 106, mechanical variations in the recording head 101 and the carriage 106 may cause the recording head 101 to be inclined with respect to the main scanning direction as shown in FIG. 24. In addition, the position at which a sensor 110 is mounted on the carriage 106 may vary according to the device. The recording head 101, if inclined with respect to the carriage 106, causes the pattern elements to be inclined as shown in FIGS. 25(b) and 25(c) although those pattern elements should be vertical bars (FIG. 25(a)). On the other hand, if the sensor read positions in the longitudinal direction of the pattern element vary as indicated by A to D, detection errors up to the value d occur.

[0013] As described above, there is a possibility in the conventional registration detection method that the pattern detection result varies greatly according to the manufacturing variations in the recording head 101, how the recording head 101 is mounted on the carriage 106, and how the sensor 110 is mounted.

[0014] Therefore, it is another object of the present invention to provide an image forming device capable of detecting a test patternt more precisely in order to precisely detect a head deviation when a recording head has been replaced.

Disclosure of Invention

[0015] An image forming device according to the present invention forms an image on a print paper in an ink jet recording method with a plurality of heads. The device comprises main scanning direction moving means for moving a carriage in a main scanning direction, the carriage having the plurality of heads mounted thereon; paper conveying means for conveying the print paper in a sub-scanning direction; pattern printing means for printing, with at least one head, a test pattern including predetermined pattern elements; pattern detecting means, mounted on the carriage, for detecting the pattern elements of the test pattern printed on the print paper by the printing means; binary conversion means for binarizing an output of the pattern detecting means; position detecting means for detecting a position of the carriage in the main scanning direction; and calculating means for moving the carriage to detect the pattern elements of the test pattern with the pattern detecting means, for detecting a print position of the pattern elements based on a detection result of the position detecting means when a rising and/or falling edge of a binary signal obtained by the binary conversion means is generated, and for calculating a mounting deviation amount of each head in the major scanning direction, wherein the position detecting means comprises low-resolution position detecting means based on a linear scale provided on a movement path of the carriage and high-resolution position detecting means for detecting a position more finely than a minimum unit determined by a

resolution of the low-resolution position detecting means. In this way, the device according to the present invention detects the position of the carriage at a time of a change in the output from the pattern detecting means, allowing the position of the pattern element to be detected precisely without being affected by the carriage speed variations generated by mechanical causes. In addition, the mounting error of each head may be obtained by finding the position of the pattern element in one single scan and by comparing it with the indicated print position of the pattern. Combining the low-resolution position detecting means with the high-resolution position detecting means makes it possible to detect the position of the pattern element more precisely.

[0016] The test pattern is, for example, at least one vertical bar extending in the sub-scanning direction almost perpendicular to the main scanning direction.

[0017] The test pattern may include, for each head and as a pattern element, at least one horizontal bar extending almost in parallel with the main scanning direction. In this case, the device further comprises conveyance amount detecting means for detecting a conveyance amount of the print paper in the sub-scanning direction almost perpendicular to the main scanning direction; and measuring means for measuring the conveyance amount equal to or smaller than the unit of the timer of the conveyance amount detecting means. The calculating means moves the print paper, on which the test pattern is printed, with the use of the paper conveying means with respect to the carriage to detect the pattern elements of the test pattern with the pattern detecting means, detects the print position of the pattern elements based on the detection results of the conveyance amount detecting means and the measuring means when a rising and/or falling edge of the binary signal obtained by the binary conversion means is generated, and calculates an amount of mounting deviation of each head in the sub-scanning direction based on the print position of the pattern elements printed by each head.

[0018] The pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

[0019] The low-resolution position detecting means comprises, for example, a counter for counting a timing signal based on the linear scale, and the high-resolution position detecting means comprises a timer which is initialized by the timing signal and measures a time with a predetermined clock signal.

[0020] The pattern printing means may cause each of different portions of a single head to print a plurality of dots sequentially in a plurality of passes, the plurality of dots constituting a portion of the vertical bar. This method, what we call multi-pass recording, reduces horizontal positional deviations at upper and lower portions of the vertical bar caused by head skews or variations in head recording elements.

[0021] The calculating means uses the pattern detecting means to detect the vertical bar at least two positions in a longitudinal direction of the vertical bar to obtain a print position of the vertical bar based on an average value of the detected results. This processing averages pattern position detection errors.

[0022] In addition, the device may further comprise means for measuring a unit time interval of the linear scale at a time the pattern elements are detected; and means for

correcting a measured value of the timer based on the measured value and a theoretical value of the unit time interval. This configuration eliminates the effect of carriage speed variations when detecting the position within the unit time interval.

[0023] Preferably, the calculating means calculates the center position of the width of the pattern element based on both edges of the obtained pattern element. This method eliminates the dependency of the position detection result upon the paper types and paper floating.

[0024] A method according to the present invention, for use on an image forming device with a linear scale provided on a carriage movement path, for detecting a deviation between a print position actually printed on a print paper by a head and a print target position comprises the steps of providing a timer for detecting a position within a unit interval determined by a resolution of the linear scale; printing a predetermined print element at the target position on the print paper by the head mounted on a carriage that scans in a major scanning direction; detecting the print element with a sensor mounted on the carriage; and detecting a low-resolution position based on the linear scale when the print element is detected and, detecting a high-resolution position within the unit interval with the timer, and obtaining the deviation between the detected position and the print target position.

Brief Description of Drawings

FIG. 1 is a diagram showing the main unit of an image forming device in an embodiment of the present invention.
FIG. 2 is a diagram showing the control block in the embodiment of the present invention;
FIG. 3 is a diagram showing a test pattern (print pattern) used in the embodiment of the present invention;
FIG. 4 is a diagram showing the configuration of a sensor used in the embodiment of the present invention;
FIG. 5 is a diagram showing the configuration of a pattern detector used in the embodiment of the present invention;
FIG. 6 is a diagram showing a print pattern and the sensor output timing in the embodiment of the present invention;
FIG. 7 is a diagram showing the timing in which a linear scale output is obtained when an interrupt is received in the embodiment of the present invention;
FIG. 8 is a diagram showing how the sensor output changes when a paper floating occurs in the embodiment of the present invention;
FIG. 9 is a diagram showing an example of print results in the embodiment of the present invention;
FIG. 10 is a diagram showing the internal circuit of a recording head in the embodiment of the present invention;
FIG. 11 is a diagram showing an image formation procedure in the embodiment of the present invention;
FIG. 12 is a diagram showing the configuration of a linear scale and a print timing in the embodiment of the present invention;
FIG. 13 is a flowchart showing an example of registration adjustment after a head is

replaced in the embodiment of the present invention;
FIGS. 14(a), 14(b), and 14(c) are diagrams showing print results when a head is deviated in position;
FIG. 15 is a diagram showing a print pattern used to detect a registration deviation in a conventional method;
FIG. 16 is a diagram showing a control circuit used to detect a pattern in the conventional method;
FIG. 17 is a diagram showing a control block in a second embodiment of the present invention;
FIG. 18 is a timing chart showing the second embodiment of the present invention;
FIG. 19 is a diagram showing the internal block of a head control unit in a third embodiment of the present invention;
FIGS. 20(a) and 20(b) are diagrams showing how multi-pass printing is performed in the embodiment shown in FIG. 19;
FIGS. 21(a) and 21(b) are diagrams showing the difference in print results between single-pass printing and multi-pass printing in the embodiment shown in FIG. 19;
FIGS. 22(a), 22(b), and 22(c) are diagrams showing a head that is inclined and print results in the embodiment show in FIG. 19;
FIG. 23 is a diagram showing how head manufacturing variations affect the jet of ink;

FIG. 24 is a diagram showing variations in the mounting of a head on a carriage; and
FIGS. 25(a), 25(b), and 25(c) are diagrams showing how variations in the mounting of a head on a carriage affect the jet of ink.

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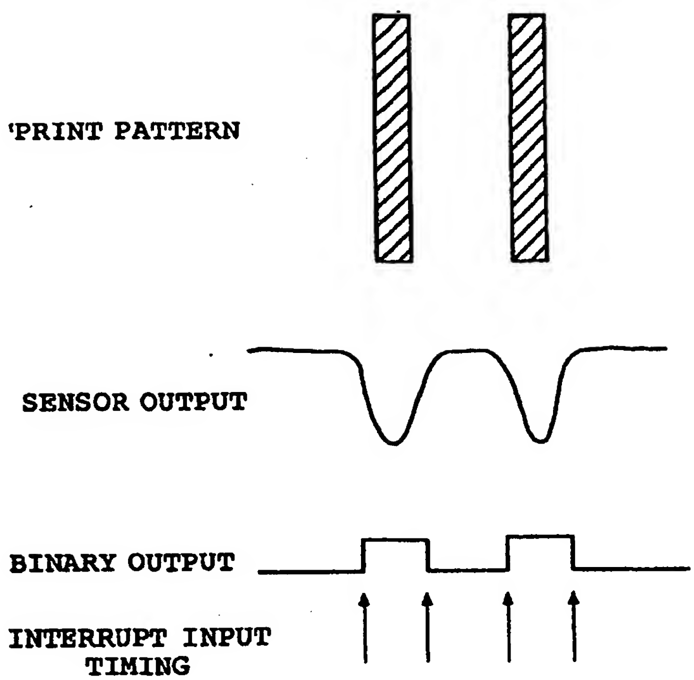
PRINT PATTERN
SENSOR OUTPUT
BINARY OUTPUT
INTERRUPT INPUT TIMING

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